EEG Spectral Analysis on Muslim Prayers

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Introduction

The brain is an electrochemical organ, which functions as the portal for integrating and processing information, as well as the controlling center (Applegate 1995; Schlogl et al. 2002). There were also several studies that showed that the brain frequency rhythm may have correlation with spiritual activities, such as yoga (Vialatte et al. 2009; Arambula et al. 2001), tai chi (Field et al. 2010), and Zen meditation (Fumoto et al. 2004). One of the most commonly studied brain wave is alpha wave, which is indicative of relaxation or mental inactivity. The production of alpha waves is normally promoted by the parasympathetic nervous system with suppression of the symphathetic system. (Applegate 1995; Takahashi et al. 2005).
Religious meditations and prayers have been found to possibly promote relaxation, as well as a healthier, more balanced condition to the human mind and body (Lee et al. 2007; Reibel et al. 2001). Banquet (1973) performed a spectral analysis during transcendental meditation and discovered that the frequency rhythm of both alpha and theta waves increased during meditation. Kasamatsu and Hirai (1966) demonstrated the appearance of alpha and theta waves during Zen meditation. In addition, Arambula et al. (2001) investigated whether the physiological response correlated with a well-trained Kundalini yoga meditator, and found that alpha wave EEG activity was enhanced during meditation when compared to the pre-and post-baselines. There has been no study conducted on Muslim prayers, except by Ibrahim et al. (2008) who

measured at the gamma waves of EEG following a prayer session. It was proposed that the practice of the Muslim prayer was capable of producing a higher state of calmness in the human mind, likely to be due to an increase in concentration and focus during the prayers. On the other hand, a number of studies found that negative side-effects were also experienced following the practice of meditations. Shapiro (1992) found that 63% of the subjects reported adverse effects during and after meditation, and 7.4% experienced profoundly adverse effects. Furthermore, Craven (1989) described uncomfortable kinaesthetic sensations, mild dissociation, feelings of guilt and, via anxiety-provoking phenomena, psychosis-like symptoms, grandiosity, elation, destructive behaviour and suicidal feelings following recorded meditation sessions.

The Muslim prayer, known as salat in Arabic, is a worshipping act which encompasses both physical movements of the body, as well as the Quranic recitations and other specific supplications. The prayer is obligatory to all Muslims and is a routine daily activity that is performed at specific prescribed time and duration (Ibrahim et al. 2008). There are four main positions involved in the prayer, namely standing, bowing, prostrating and sitting. In addition to these physical movements, a fundamental part of the Muslim prayer is the recitation of Quranic verses and specific supplications that must be verbalized when the worshipper assumed certain positions and performed specific movements.

In addition to the obligatory prayer, there are other optional prayers such as Dhuha prayers that Muslims voluntarily perform for certain reasons. Dhuha prayer is performed for the purpose of expressing gratitude for the new day and appealing for good fortune, commonly performed in the morning. This paper presents the alpha wave signal activity in the brain of Muslim subjects while performing their Dhuha prayer.

Materials and Methods

Subjects

Nine Muslim subjects between 20 and 29 years old were recruited in this study (six males and three females). None of them reported any neurological or psychiatric disorder, and a consent form was obtained from each subject.

EEG Recording

The EEG data was recorded from eight electrode positions on the scalp (homologous frontal (F3, F4), central (C3, C4), parietal (P3, P4) and occipital (O1, O2) sites) according to the International 10–20 system of electrode placement, referenced to the linked ear lobe electrode (Fig. 1). These electrode sites selections were based on previous studies that recorded EEG during meditations or relaxation techniques (Surwillo and Hobson 1978; Uebaba et al. 2005; Sim and Grewal 1989; Takahashi et al. 2005). Electrode impedance was less than 5 k ohm. The signals were sampled at a frequency of 250 Hz and recorded using the MP150 EEG acquisition system (BIOPAC Systems Inc., California, USA).

The experimental protocol for each of the subjects consisted of three sessions. The first sessions commenced with the subjects sitting on a chair in a relaxed position with their eyes opened for 1 min then they were asked to close their eyes for another minute; and finally to open their eyes for another minute. The EEG was subsequently recorded and the data were used as a baseline for consecutive analyses. The subjects were asked to relax for an additional 3 min prior to the commencement of the second sessions.

In the second sessions, the subjects performed the Dhuha prayer for four cycles. The prayer began with the

upright standing position, which took approximately 30–60 s to complete. It was followed by bowing; with the trunk of the body being fully horizontal at 90-degree angle with the legs, and both hands pressing down on the knees. The subject then recited a specific supplication during this position that took approximately 5 s to complete. The subject then briefly stood up for approximately 2 s, before subsequently prostrating with both palms and the knees touching the floor. This position lasted for about 10 s, with

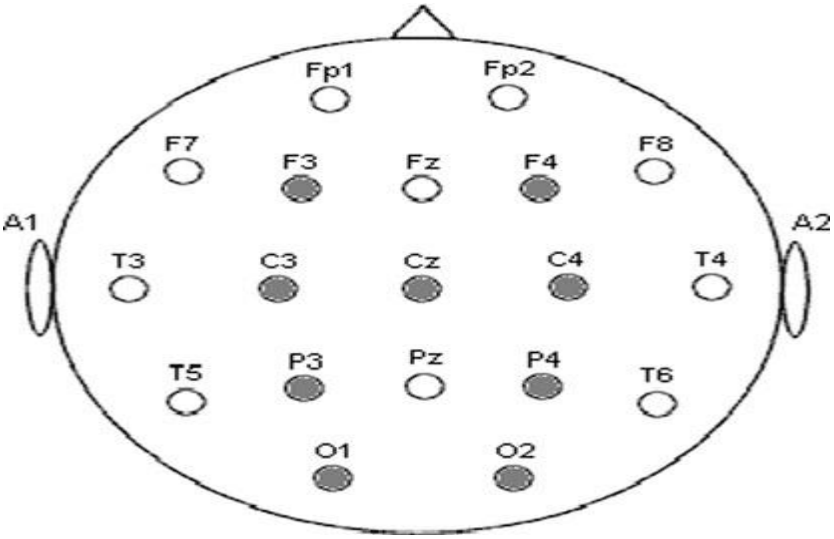

Fig. 1 Electrode positions on the scalp

the subject reciting a specific supplication. The subject then sat and recited a supplication for about 5 s, followed by a second prostration. Finally the subject sat for the second time, lasting for about eight seconds, completing a single cycle of the prayer movements as shown in Fig. 2a. The subject then stood to continue with the subsequent cycles of movements (Fig. 2b, c). The only difference lies in the final cycle, where the subject took approximately 20–30 s to complete the recitation. At the end of the recitation, the subject gave salam, which indicated the end of the prayer (Fig. 2d). Subjects were reminded to keep their eyes opened during the prayer session.

In the third sessions, the subjects were instructed to

perform the physical movements of the prayer without reciting any Quranic verses or supplications. The subjects were only required to act out the salat positions in the proper sequence without actually praying. The acted sequence was repeated for four cycles and each position took approximately 15 s.

Signal Analysis

To avoid any artifacts due to physical movements, only four static positions (standing, bowing, sitting and prostrating) were analyzed, while the signal in between movements were excluded. The EEG data was filtered using Finite Impulse Response (FIR) band-pass filter between 1.0 and 100 Hz with the number of coefficient is 4,000 and Hanning window with 50% overlap. Fast Fourier Transform (FFT) was then performed to the selected data for every 1 s segment and the power spectral density (PSD) data in (lv^2) was obtained. The PSD was segmented into alpha (8–13 Hz) and into the generic EEG brain wave (0–95 Hz). Alpha relative power (RPa) representing the energy of the signal in the frequency range was calculated as follows